US011325430B2

(12) **United States Patent**
Kamada

(10) **Patent No.: US 11,325,430 B2**
(45) **Date of Patent: May 10, 2022**

(54) **TIRE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/760,132**

(22) PCT Filed: **Oct. 17, 2018**

(86) PCT No.: **PCT/JP2018/038592**
§ 371 (c)(1),
(2) Date: **Apr. 29, 2020**

(87) PCT Pub. No.: **WO2019/087776**
PCT Pub. Date: **May 9, 2019**

(65) **Prior Publication Data**

US 2020/0346497 A1 Nov. 5, 2020

(30) **Foreign Application Priority Data**

Oct. 30, 2017 (JP) JP2017-209049

(51) **Int. Cl.**
B60C 13/02 (2006.01)
B60C 13/00 (2006.01)
B60C 13/04 (2006.01)

(52) **U.S. Cl.**
CPC ***B60C 13/02*** (2013.01); ***B60C 13/002*** (2013.01); *B60C 2013/045* (2013.01); *B60C 2200/04* (2013.01)

(58) **Field of Classification Search**
CPC B60C 13/00; B60C 13/001; B60C 13/002; B60C 13/02
See application file for complete search history.

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(57) **ABSTRACT**

A protrusion portion (**110**) of a pneumatic tire is formed by a plurality of protrusion parts (**111**) extended along a tire circumferential direction. The protrusion parts (**111**) are arranged with predetermined gaps therebetween so as to form a circle along the tire circumferential direction. A length (**S1**) of the protrusion part (**111**) in the tire circumferential direction is larger than a maximum width (**W1**) of the protrusion part (**111**) in a tire radial direction. In a tire side view, a narrow groove (**200**) extended along the tire circumferential direction is formed on a surface (**111***s*) of the protrusion part (**111**).

11 Claims, 9 Drawing Sheets

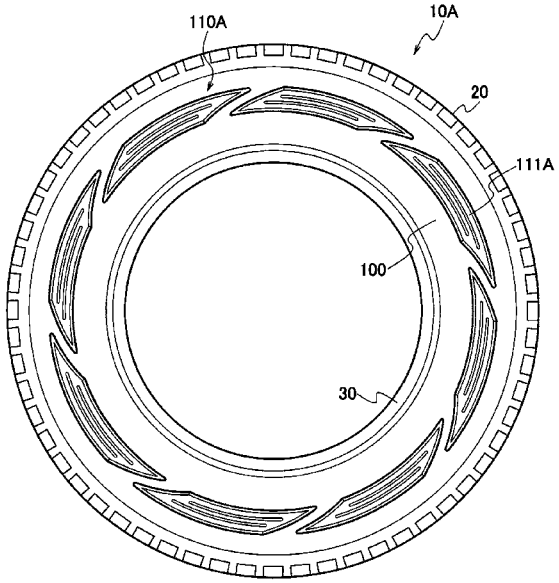

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FIG. 1

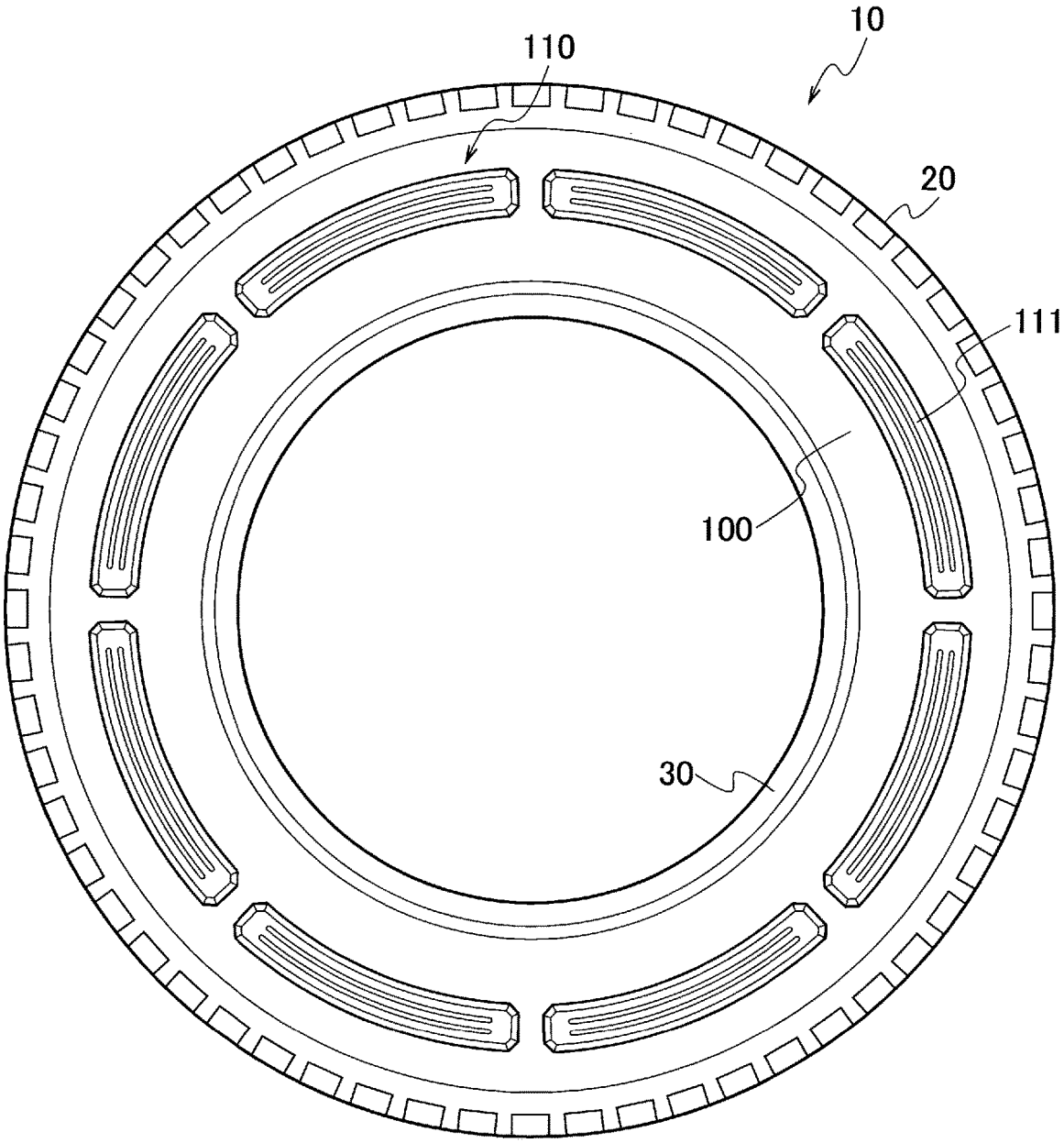


FIG. 2

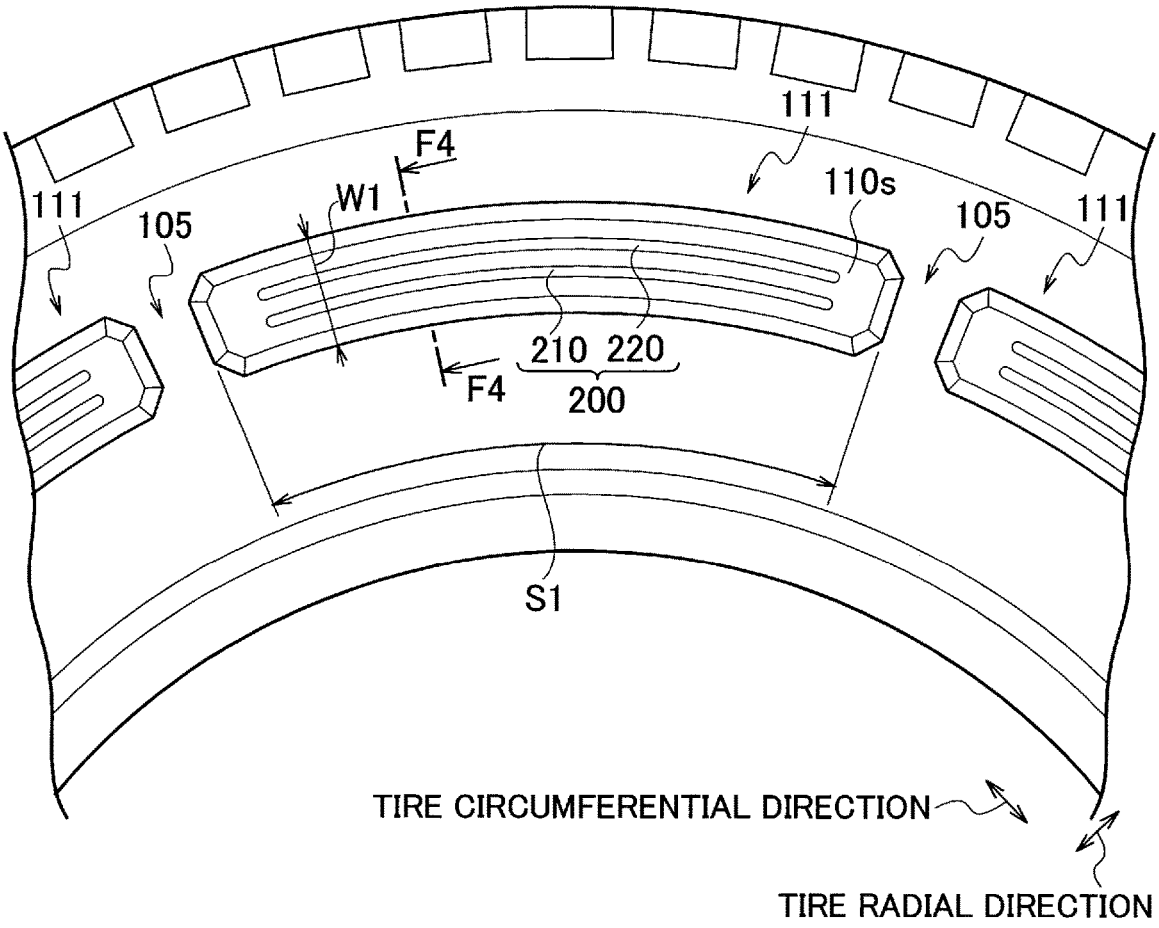

111
F4
W1
111
105
110s
105
111
210 220
F4
200
S1
TIRE CIRCUMFERENTIAL DIRECTION
TIRE RADIAL DIRECTION

FIG. 3

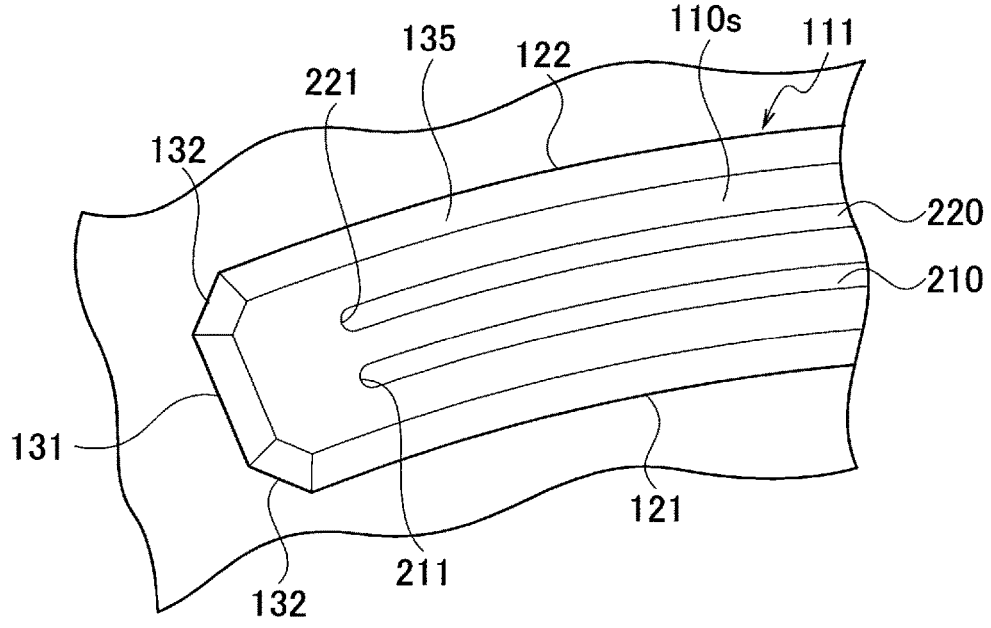

135
122
110s
111
221
132
220
210
131
121
211
132

FIG. 4

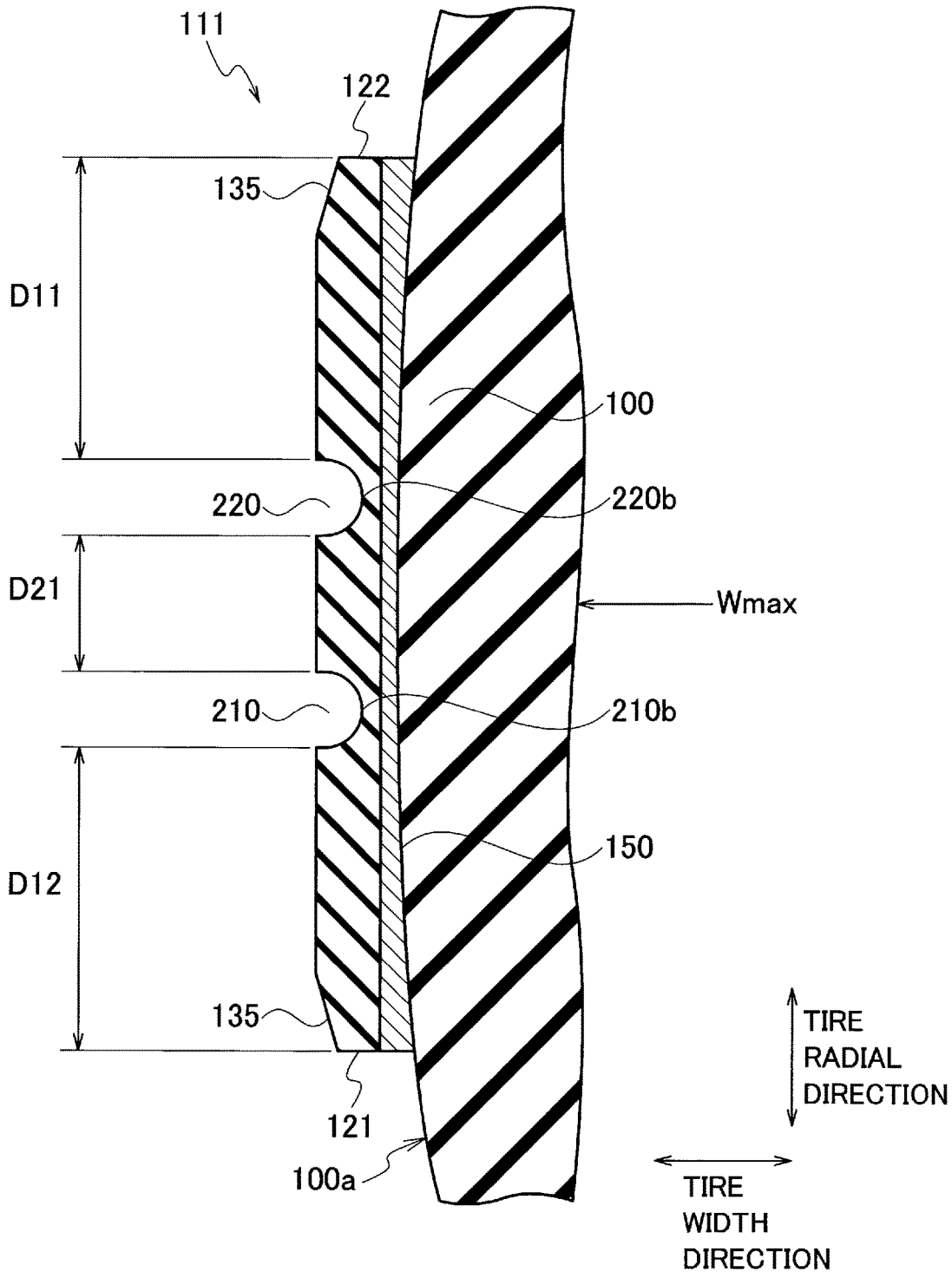

111
122
135
D11
100
220
220b
D21
Wmax
210
210b
D12
150
135
121
100a
TIRE
RADIAL
DIRECTION
TIRE
WIDTH
DIRECTION

FIG. 5

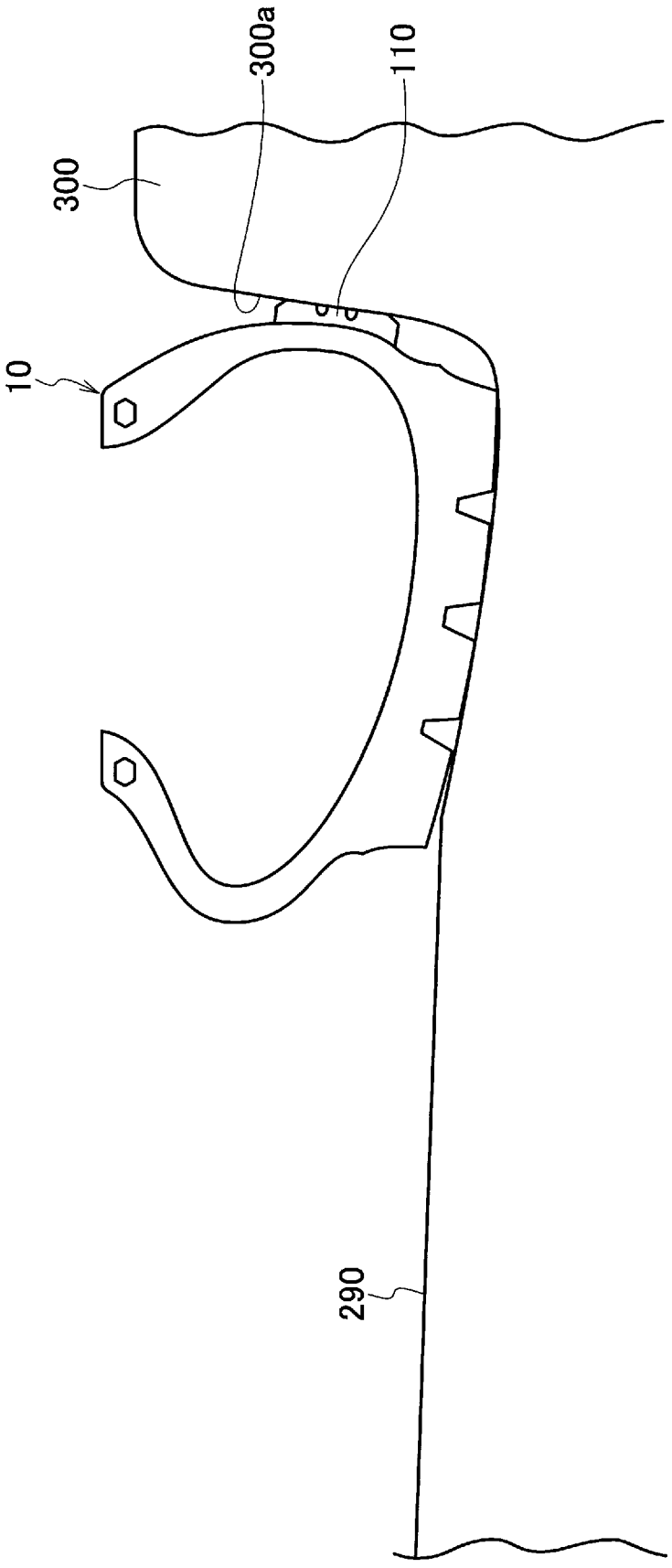
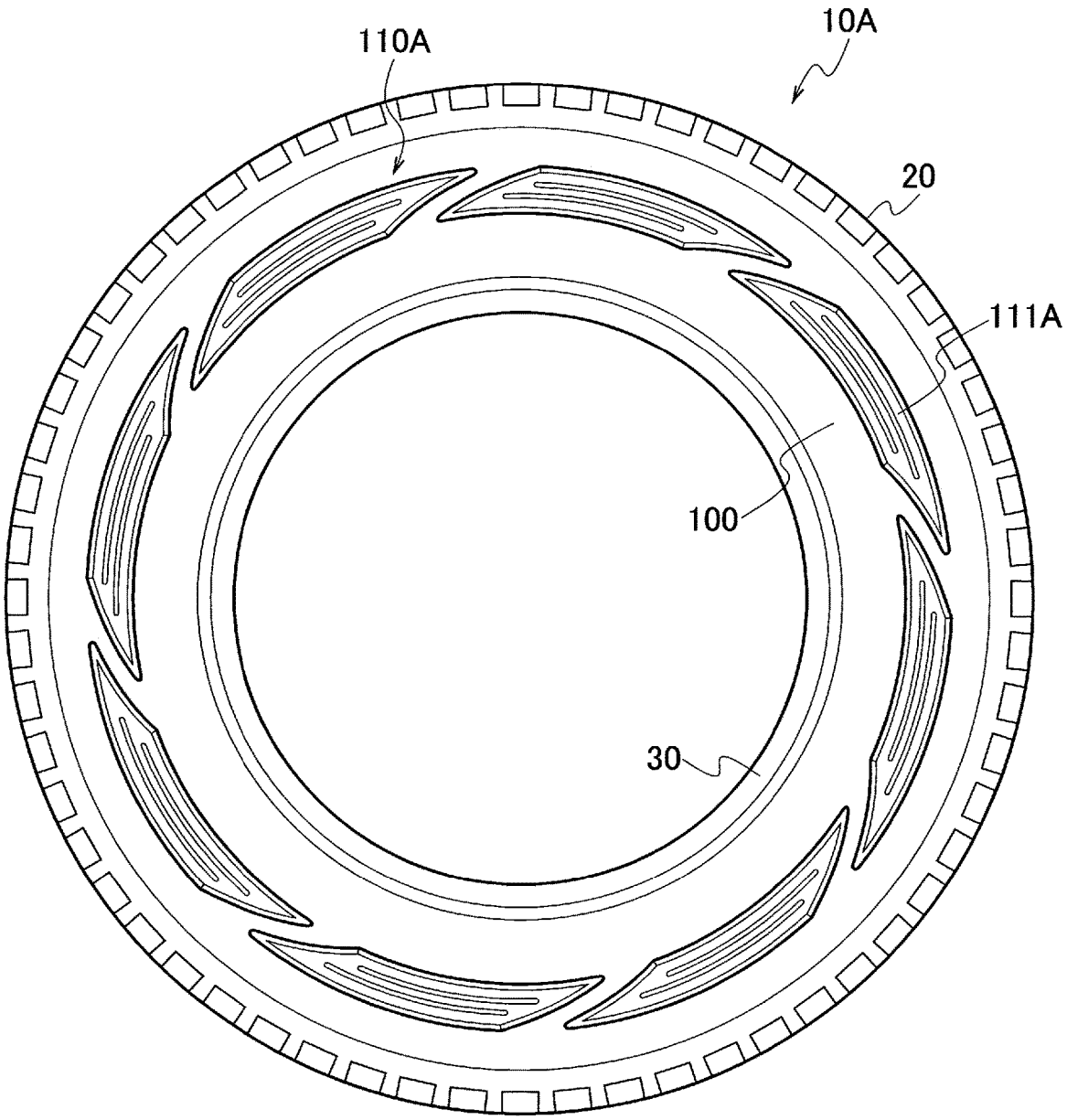


FIG. 6



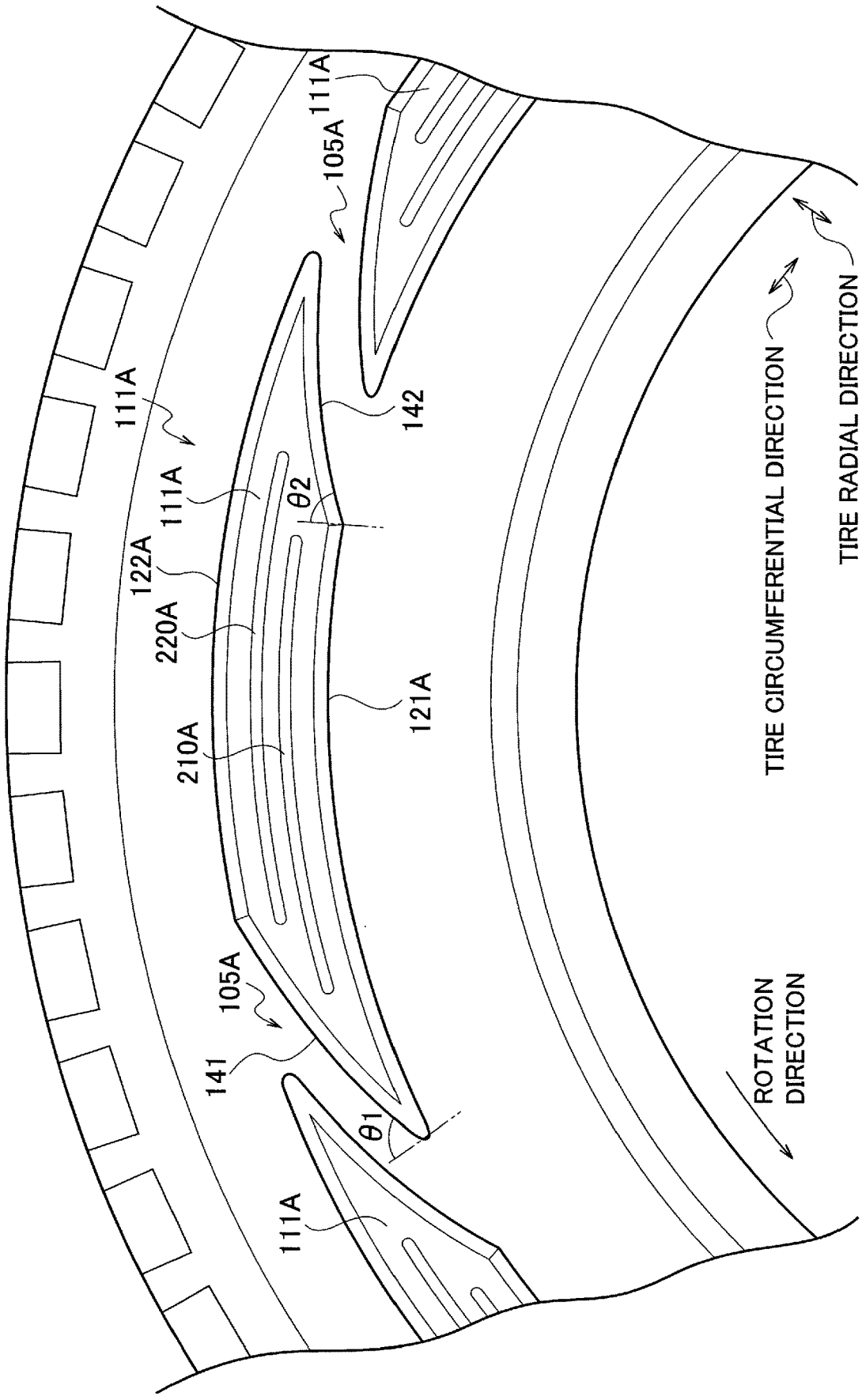

111A
105A
111A
142
θ2
111A
122A
220A
210A
121A
105A
141
θ1
111A
TIRE CIRCUMFERENTIAL DIRECTION
TIRE RADIAL DIRECTION
ROTATION DIRECTION

FIG. 7

FIG. 8

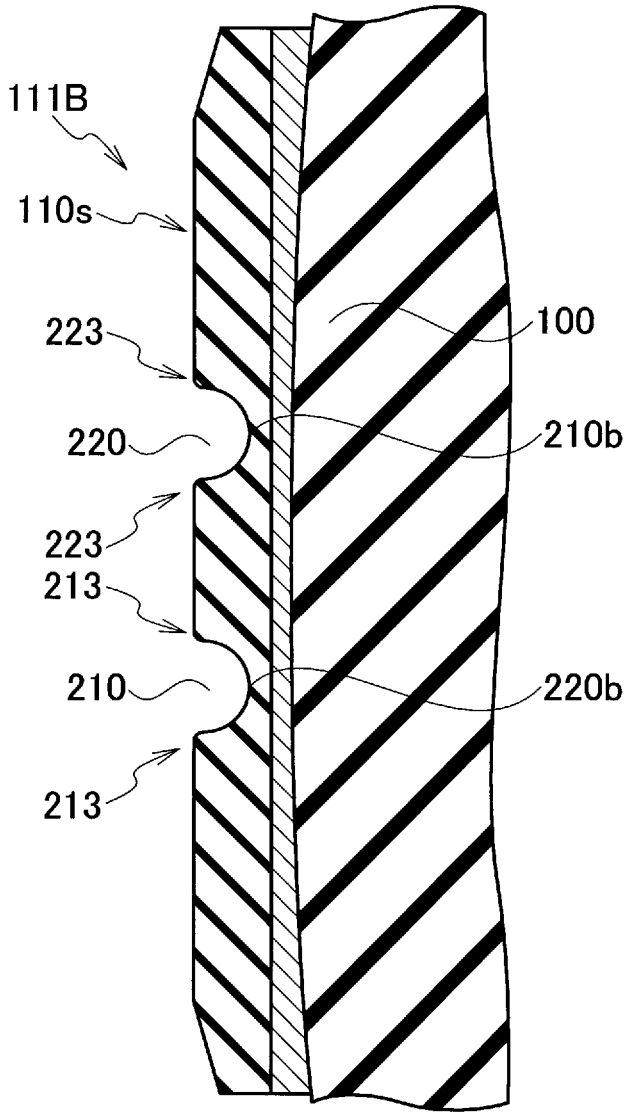


FIG. 9

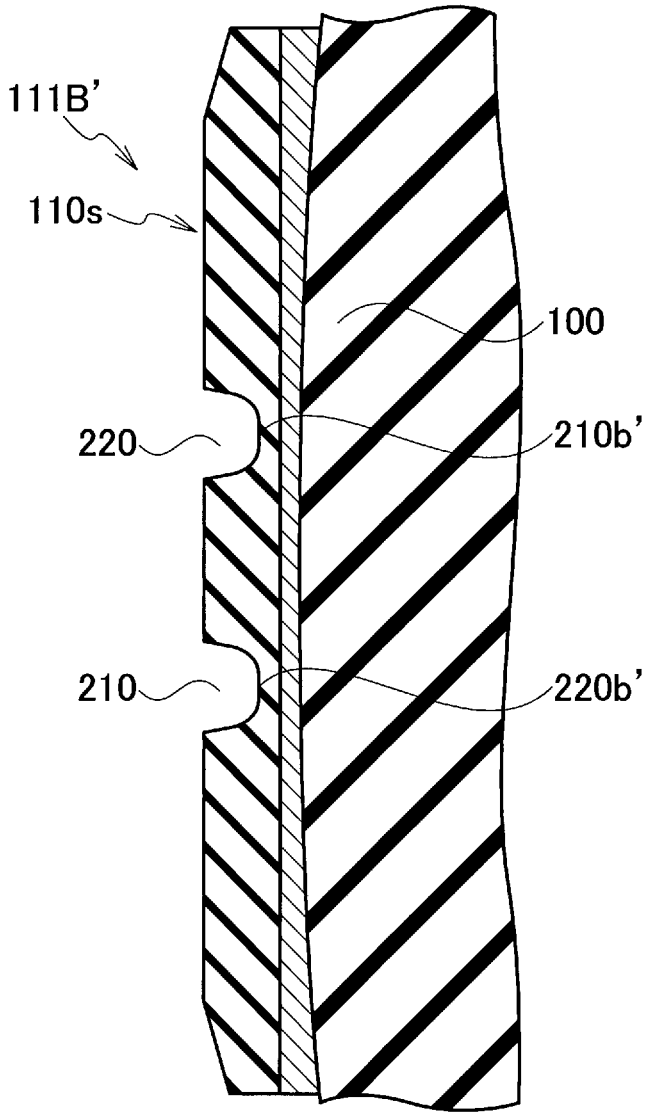
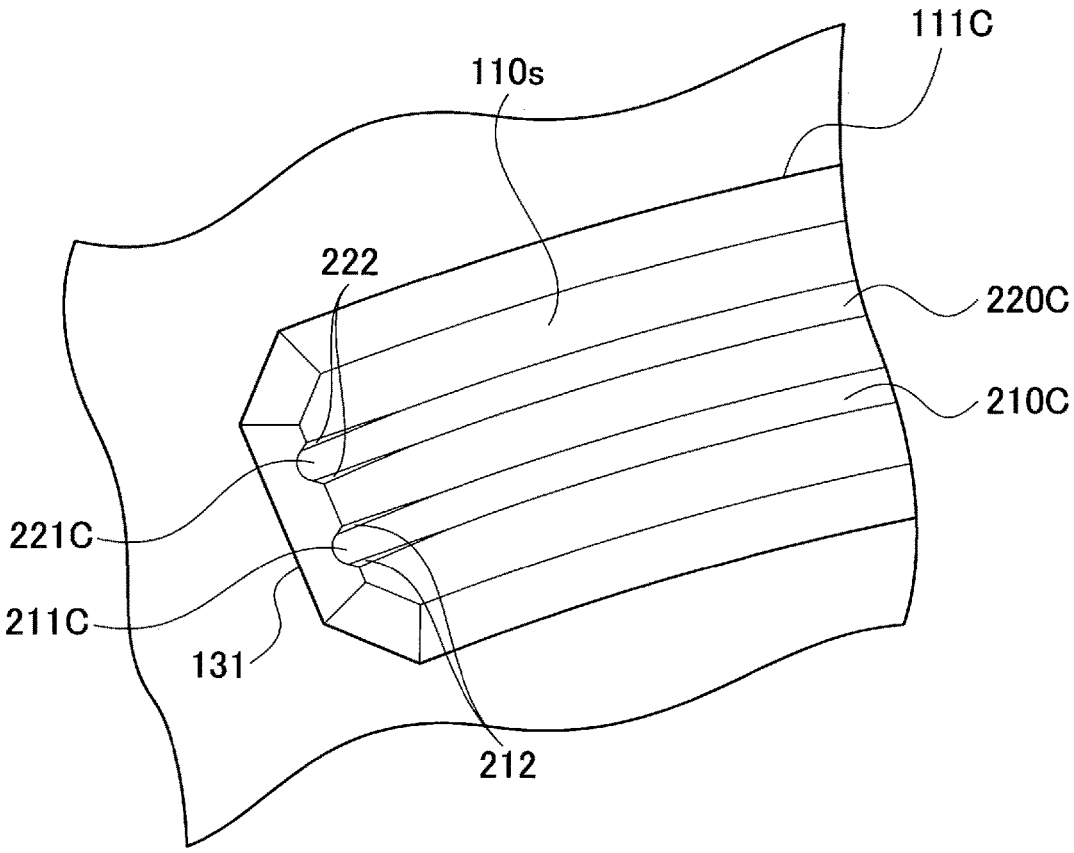


FIG. 10



TIRE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a National Stage of International Application No. PCT/JP2018/038592, filed Oct. 17, 2018, claiming priority to Japanese Patent Application No. 2017-209049, filed Oct. 30, 2017.

TECHNICAL FIELD

The present invention relates to a tire capable of dealing with wear of a tire side portion, the tire being suitable to a demand for precision docking with high precision, in particular relates to a tire having a protrusion portion protruded from a surface of a side wall toward an outer side in a tire width direction.

BACKGROUND ART

Conventionally, a structure of a tire for trucks or buses that has a protrusion portion on a surface of a side wall in order to prevent damage of a tire side portion, specifically a surface of the side wall, caused by contacting a curbstone of a sidewalk, has been known.

For example, Patent Literature 1 discloses a tire for trucks or buses having a wing-like protrusion portion, which is protruded toward an outer side in a tire width direction, on a surface of a side wall closer to a tread.

The tire for trucks or buses is presupposed to be re-treaded (cold re-treaded) by using a vulcanized rubber sheet for a tread. Its object is to prevent the damage of a tire side portion of a base tire, which is to be extended in its lifetime by the re-treading forming the wing-like protrusion portion, so as to improve durability of the tire.

CITATION LIST

Patent Literature

[PTL 1] Japanese Unexamined Patent Application Publication No. 2005-112010

SUMMARY OF INVENTION

In recent years, it is desired to improve so-called precision docking of a route bus that repeatedly stops at bus stops. The precision docking denotes a degree of a distance and a degree of a level difference between a sidewalk and a doorway when the bus stops at a bus stop. The getting on/off performance is enhanced by improving the precision docking.

However, when the precision docking is improved, the surface of the side wall of the tire is rubbed with a curbstone of the sidewalk and the tire side portion is severely worn, and as a result, the failure of the tire might be caused. It is accordingly considered to form the protrusion portion described above on the side wall and to replace (also called re-side) a part of the side wall including the protrusion portion depending on the wear.

However, in a case in which the protrusion portion is merely formed, the protrusion portion is not worn evenly, and therefore the side wall might be replaced although a part of the protrusion portion is largely remained.

Such a situation is unfavorable from a viewpoint of suppression of a cost for manufacturing and maintaining the tire and protection for the environment. Further, the increase of the rolling resistance and the weight caused by forming the protrusion portion should be avoided as much as possible due to a desire to improve an environmental performance.

Also, in a case in which the protrusion portion is merely formed, advertent stress is applied to the protrusion portion, and as a result, damage such as a crack might be generated in or around the protrusion portion.

Accordingly, an object of the present invention is, in consideration of the problem described above, to provide a tire for which a side wall having a protrusion portion thereon can be replaced, the tire being capable of achieving both of sufficient durability of the protrusion portion and high environment performance of the tire.

One aspect of the present invention is a tire (for example, pneumatic tire **10**) including a protrusion portion (for example, protrusion portion **110**) protruded from a surface of a side wall (side wall **100***a*) toward an outer side in a tire width direction. The protrusion portion is formed by a plurality of protrusion parts (protrusion parts **111**) extended along a tire circumferential direction. The protrusion parts are arranged with predetermined gaps (gaps **105**) therebetween so as to form a circle along the tire circumferential direction. A length of the protrusion part in the tire circumferential direction (tire circumferential direction size S1) is larger than a maximum width (maximum width W1) of the protrusion part in a tire radial direction. In a tire side view, a narrow groove (narrow groove **200**) extended along the tire circumferential direction is formed on a surface (surface **110***s*) of the protrusion part.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a side view illustrating a whole of a pneumatic tire **10**.

FIG. **2** is an enlarged side view illustrating a part of a protrusion portion **110**.

FIG. **3** is an enlarged side view illustrating a part of a protrusion part **111**.

FIG. **4** is a cross-sectional view illustrating a part of a tire side portion **100** including the protrusion part **111** taken along line F**4**-F**4** in FIG. **2**.

FIG. **5** is a schematic view illustrating the pneumatic tire **10**, which is mounted to a vehicle (not shown), contacting a curbstone **300**.

FIG. **6** is a side view illustrating a whole of a pneumatic tire **10**A according to a modified example.

FIG. **7** is an enlarged side view illustrating a part of a protrusion portion **110**A.

FIG. **8** is a cross-sectional view illustrating a part of a tire side portion **100** including a protrusion part **111**B according to another modified example.

FIG. **9** is a cross-sectional view illustrating a part of a tire side portion **100** including a protrusion part **111**B' according to another modified example.

FIG. **10** is an enlarged side view illustrating a part of a protrusion part **111**C according to the other modified example.

DESCRIPTION OF EMBODIMENTS

Hereinafter, an embodiment of the present invention will be described with reference to the drawings. The same reference signs or similar reference signs are assigned to the same functions or the same components and the description thereof is omitted as needed.

(1) Schematic Whole Configuration of Tire

FIG. **1** is a side view illustrating a whole of a pneumatic tire **10**. The pneumatic tire **10** is formed as a radial tire for trucks or buses (heavy load pneumatic tire), especially formed as a tire mounted to a route bus that repeatedly stops at bus stops. A size of the pneumatic tire **10** is not especially limited, however examples of a general size of the tire used for the route bus include 275/70R22.5, 245/70R19.5 and 205/80R17.5.

The pneumatic tire **10** is provided with a tread portion **20** that contacts a road surface, and a bead portion **30** mounted to a wheel rim (not shown). Further, the pneumatic tire **10** is provided with a tire side portion **100** formed between the tread portion **20** and the bead portion **30**.

Although it is not illustrated in FIG. **1** and others, similar to a general heavy load pneumatic tire, the pneumatic tire **10** is provided with a carcass ply that forms a frame of the pneumatic tire **10**, a pair of crossing belt layers arranged at an inner side of the tread portion **20** in a tire radial direction, and the like.

In the tread portion **20**, a pattern (tread pattern) suitable to a property of a vehicle (bus) to which the pneumatic tire **10** is mounted (for example, a mainly low speed travelling vehicle or a mainly high speed travelling vehicle) and performance of the pneumatic tire **10** to be required (for example, low rolling resistance or wear resistance) is formed.

A protrusion portion **110** is formed on the tire side portion **100**. The protrusion portion **110** is formed on a surface of a side wall **100***a* that forms an outer side wall surface of the tire side portion **100**.

The protrusion portion **110** is protruded from the surface of the side wall **100***a* toward an outer side in the tire width direction. The protrusion portion **110** contacts a curbstone **300** (not shown in FIG. **1**, see FIG. **5**) first when the vehicle stops at a bus stop.

The protrusion portion **110** is formed by a plurality of protrusion parts **111** extended along a tire circumferential direction. In the present embodiment, the protrusion portion **110** is formed by eight protrusion parts **111** extended along the tire circumferential direction.

In this way, the protrusion parts **111** are arranged with predetermined gaps therebetween in the tire circumferential direction. That is, the protrusion parts **111** are arranged with the predetermined gaps therebetween so as to form a circle along the tire circumferential direction.

The protrusion part **111** is formed of a rubber material similar to the tire side portion **100**. The protrusion part **111** may be formed of a rubber material having a friction coefficient lower than that of the other part in the tire side portion **110**.

For example, a filler within a specific compounded range and a specific amide compound are added to the rubber composition adopted for the protrusion part **111**. Specifically, the rubber composition contains 30 parts by mass or more of carbon black, 10 parts by mass or less of silica, and 0.1-10 parts by mass of fatty acid amide based on 100 parts by mass of a rubber component.

The rubber component preferably contains 50 mass % or more of a diene rubber, more preferably 80 mass % or more of the diene rubber, most preferably 100 mass % of the diene rubber.

Examples of the diene rubber include a natural rubber (NR), a polyisoprene rubber (IR), a polybutadiene rubber (BR), a styrene-butadiene copolymer rubber (SBR), an ethylene-propylene-diene rubber (EPDM), a chloroprene rubber (CR), a butyl rubber (IIR), a halogenated butyl rubber, and an acrylonitrile-butadiene rubber (NBR).

The carbon black contained in the rubber composition is not especially limited. The carbon black having the grade of IISAF, N339, HAF, FEF, or GPF may be adopted. The fatty acid amide having a carbon number of 8-22 is preferable as the fatty acid amide contained in the rubber composition. Examples of the fatty acid amide include caprylic acid amide, lauric acid amide, myristic acid amide, palmitic acid amide, stearic acid amide, behenic acid amide, erucic acid amide, oleic acid amide, linoleic acid amide, and linolenic acid amide.

(2) Configuration of Protrusion Portion **110**

Next, a specific configuration of the protrusion portion **110** will be described. FIG. **2** is an enlarged side view illustrating a part of the protrusion portion **110**.

As shown in FIG. **2**, the protrusion parts **111** adjacent to each other are arranged with a gap **105** therebetween so as to form a circle along the tire circumferential direction. In the present embodiment, the gaps **105** between the eight protrusion parts **111** are identical. That is, the protrusion parts **111** are arranged at the same intervals in the tire circumferential direction.

A length of the protrusion part **111** in the tire circumferential direction (tire circumferential direction size S1) is larger than a maximum width W1 of the protrusion part **111** in the tire radial direction. That is, in a tire side view, the protrusion part **111** is formed in an arc shape having a predetermined width in the tire radial direction. In other words, the protrusion part **111** is a band with an arc shape extended in the tire circumferential direction.

Further, as shown in FIG. **2**, in the tire side view, a narrow groove **200** extended along the tire circumferential direction is arranged on a surface **110***s* of the protrusion part **111**.

Specifically, the narrow groove **200** includes a first narrow groove **210** and a second narrow groove **220**. The first narrow groove **210** is arranged at an inner side in the tire radial direction. The second narrow groove **220** is arranged at an outer side in the tire radial direction with respect to the first narrow groove **210**.

Each of the first narrow groove **210** and the second narrow groove **220** is formed in an arc shape extended in the tire circumferential direction, similar to the protrusion part **111**.

FIG. **3** is an enlarged side view illustrating a part of the protrusion part **111**. As shown in FIG. **3**, in the tire side view, the protrusion part **111** includes an inner side portion **121** extended along the tire circumferential direction at an inner side in the tire radial direction and an outer side portion **122** extended along the tire circumferential direction at an outer side in the tire radial direction with respect to the inner side portion **121**.

The protrusion part **111** further includes a radial direction side portion **131** extended in the tire radial direction. The radial direction side portion **131** is continued to one end of the inner side portion **121** and one end of the outer side portion **122**.

In the present embodiment, a corner of the protrusion part **111** where the inner side portion **121** and the radial direction side portion **131** intersect to each other is chamfered in the tire side view. The other end side of the protrusion part **111** in the tire circumferential direction is similar to that described above (see FIG. **2**). Specifically, a chamfered portion **132** is formed on the corner of the protrusion part **111**.

Further, in the present embodiment, an outer peripheral portion of the surface **110***s* of the protrusion part **111** is chamfered in the tire side view. Specifically, a corner where the surface **110***s* of the protrusion part **111** and the inner side portion **121** intersect to each other is chamfered.

More specifically, a chamfered portion **135** is formed on the corner of the protrusion part **111**. Similarly, a corner where the surface **110***s* and the outer side portion **122** intersect to each other and a corner where the surface **110***s* and the radial direction side portion **131** intersect to each other are also chamfered. That is, the chamfered portion **135** is arranged to form a circle on the outer peripheral portion of the protrusion part **111**.

The narrow groove **200**, namely each of the first narrow groove **210** and the second narrow groove **220**, is not opened to an end of the protrusion part **111** in the tire circumferential direction but terminated within the protrusion part **111**. Specifically, each of the first narrow groove **210** and the second narrow groove **220** is not opened to the radial direction side portion **131** but terminated within the protrusion part **111**.

Further, in the tire side view, an end of the narrow groove **220** (first narrow groove **210** and second narrow groove **220**) in the tire circumferential direction is formed round without an edge. Specifically, an end **211** of the first narrow groove **210** is formed in a semicircular shape in the tire side view. Also, an end **221** of the second narrow groove **220** is formed in a semicircular shape in the tire side view. That is, each of the end **211** and the end **221** is formed in a shape having a curvature (round shape).

FIG. **4** is a cross-sectional view illustrating a part of the tire side portion **100** including the protrusion part **111** taken along line F**4**-F**4** in FIG. **2**. As shown in FIG. **4**, the protrusion part **111** is protruded from the side wall **100***a* to an outer side in the tire width direction.

The protrusion part **111** is formed on the side wall **100***a* via an adhesive rubber layer **150**. In the present embodiment, a thickness of the protrusion part **111** in the tire width direction is 3.0 mm, a thickness of the adhesive rubber layer **150** in the tire width direction is 1.5 mm. A whole or a part of the adhesive rubber layer **150** may be removed together with the protrusion part **111** when the worn protrusion part **111** is replaced (re-side). Further, in the present embodiment, only the worn protrusion part **111** is presupposed to be replaced, however a part of the tire side portion **100** (specifically, the side wall **100***a*) may be replaced together with the protrusion part **111**.

A width of each of the first narrow groove **210** and the second narrow groove **220** in the tire radial direction is 3.5 mm. A width of the chamfered portion **135** is also 3.5 mm. A height (thickness) of each of the inner side portion **121** and the outer side portion **122** in the tire width direction is 2.0 mm. That is, by forming the chamfered portion **135**, the height of each of the inner side portion **121** and the outer side portion **122** is lower than the height of the surface **110***s* by 1.0 mm.

A position of the protrusion part **111** in the tire radial direction is not especially limited, however considering the contact with the curbstone **300** (see FIG. **5**), it may be considered that the protrusion part **111** is arranged in a region including a maximum width position Wmax in the tire width direction.

In the present embodiment, a distance D**11** between an outer end of the protrusion part **111** in the tire radial direction (position of the outer side portion **122**) and an outer end of the second narrow groove **220** in the tire radial direction is longer than a distance D**21** between an outer end of the first narrow groove **210** in the tire radial direction and an inner end of the second narrow groove **220** in the tire radial direction.

Further, a distance D**12** between an inner end of the protrusion part **111** in the tire radial direction (position of the inner side portion **121**) and an inner end of the first narrow groove **210** in the tire radial direction is longer than the distance D**21** between the outer end of the first narrow groove **210** in the tire radial direction and the inner end of the second narrow groove **220** in the tire radial direction.

That is, a length of the surface **110***s* between the end of the protrusion part **111** and the end of the narrow groove **200** in the tire radial direction is longer than a length of the surface **110***s* between the first narrow groove **210** and the second narrow groove **220**.

In the present embodiment, as shown in FIG. **4**, a groove bottom of the narrow groove **200** is formed round without an edge in a sectional view along the tire width direction and the tire radial direction. That is, the groove bottom of the narrow groove **200** formed in a shape having a curvature (round shape).

Specifically, a groove bottom **210***b* of the first narrow groove **210** is formed in a semicircular shape. Also, a groove bottom **220***b* of the second narrow groove **220** is formed in a semicircular shape.

(3) Functions and Effects

Next, effects of the pneumatic tire **10** having the protrusion portion **110** will be described. FIG. **5** is a schematic view illustrating the pneumatic tire **10**, which is mounted to a vehicle (not shown), contacting the curbstone **300**.

As shown in FIG. **5**, when the vehicle travelling on the road surface **290** approaches the curbstone **300**, the protrusion portion **110** of the pneumatic tire **10** contacts a side surface **300***a* of the curbstone **300** first. With this, wear of the tire side portion **100** (the surface of the side wall **100***a*) caused by being rubbed directly with the curbstone **300** and failure caused by the wear can be prevented.

In this way, the protrusion portion **110** is served as a sacrificial worn portion that is worn prior to other part.

The protrusion portion **110** is formed by the protrusion parts **111** arranged with the predetermined gaps therebetween so as to form a circle along the tire circumferential direction. With this, only the protrusion part **111**, which is worn largely, can be replaced (re-side).

Further, since the gap **105** is formed between the protrusion parts **111** adjacent to each other, an amount of rubber can be decreased while securing a necessary function of the protrusion portion **110** that protects the tire side portion **100**. With this, a weight increase of the pneumatic tire **10** can be suppressed and thereby the rolling resistance thereof can be decreased.

Further, the tire circumferential direction size S**1** of the protrusion part **111** is larger than the maximum width W**1** of the protrusion part **111** in the tire radial direction. In the tire side view, the narrow groove **200** extended along the tire circumferential direction is formed on the surface **110***s* of the protrusion part **111**.

With this, even when the protrusion part **111** contacts the side surface **300***a* of the curbstone **300** and thereby the stress is caused in the protrusion part **111**, the stress is hardly concentrated on a specific part of the protrusion part **111** and therefore the durability of the protrusion part **111** can be improved.

That is, according to the pneumatic tire **10** for which the side wall **100***a* having the protrusion portion **110** thereon can

be replaced, both of sufficient durability of the protrusion portion **110** and high environment performance of the pneumatic tire **10** can be obtained.

In the present embodiment, the narrow groove **200** (first narrow groove **210** and second narrow groove **220**) is not opened to the end of the protrusion part **111** in the tire circumferential direction (radial direction side portion **131**) but terminated within the protrusion part **111**.

Thus, the end of the narrow groove **200** in the tire circumferential direction is not exposed to the radial direction side portion **131**, and thereby it can be avoided that the stress is concentrated on a specific part of the radial direction side portion **131** when contacting the curbstone **300**. With this, a possibility of a crack caused in the protrusion part **111** can be decreased and the durability of the protrusion part **111** can be further improved.

In the present embodiment, the narrow groove **200** is formed by two narrow grooves of the first narrow groove **210** arranged at the inner side in the tire radial direction and the second narrow groove **220** arranged at the outer side in the tire radial direction with respect to the first narrow groove **210**. With this, the strain on the surface **110***s* due to the deformation of the protrusion part **111** when contacting the curbstone **300** can be dispersed efficiently.

In particular, in the present embodiment, the distance D**11** between the outer end of the protrusion part **111** in the tire radial direction (position of the outer side portion **122**) and the outer end of the second narrow groove **220** in the tire radial direction is longer than the distance D**21** between the outer end of the first narrow groove **210** in the tire radial direction and the inner end of the second narrow groove **220** in the tire radial direction. Further, the distance D**12** between the inner end of the protrusion part **111** in the tire radial direction (position of the inner side portion **121**) and the inner end of the first narrow groove **210** in the tire radial direction is longer than the distance D**21** between the outer end of the first narrow groove **210** in the tire radial direction and the inner end of the second narrow groove **220** in the tire radial direction.

That is, the length of the surface **110***s* between the end of the protrusion part **111** and the end of the narrow groove **200** in the tire radial direction is longer than the length of the surface **110***s* between the first narrow groove **210** and the second narrow groove **220**.

With this, it can be prevented that, when contacting the curbstone **300**, the stress is concentrated on the first narrow groove **210** and the second narrow groove **220**, in particular the groove bottom **210***b* and the groove bottom **220***b*. Further, in the present embodiment, each of the groove bottom **210***b* and the groove bottom **220***b* is formed round without an edge in the sectional view along the tire width direction and the tire radial direction. With this, a possibility of a crack caused in the groove bottom **210***b* and the groove bottom **220***b* can be decreased and the durability of the protrusion part **111** can be further improved.

In the present embodiment, in the tire side view, the protrusion part **111** is formed in an arc shape having a predetermined width in the tire radial direction, and the chamfered portion **132** is formed on the protrusion part **111**. With this, it can be avoided that the stress is concentrated on the corner of the protrusion part **111**. Consequently, a possibility of a crack caused in the protrusion part **111** can be decreased and the durability of the protrusion part **111** can be further improved.

(4) Other Embodiments

As described above, the contents of the present invention are described with reference to the examples, however the present invention is not limited to those descriptions. It is obvious for a person skilled in the art to adopt various modifications and improvement.

For example, the protrusion portion **110** described above may be modified as below. FIG. **6** is a side view illustrating a whole of a pneumatic tire **10**A according to a modified example. Hereinafter, a configuration different from that of the pneumatic tire **10** described above is mainly described.

As shown in FIG. **6**, a protrusion portion **110**A is firmed on a tire side portion **100** of the pneumatic tire **10**A. The protrusion portion **110**A is formed by a plurality of protrusion parts **111**A extended along the tire circumferential direction. The protrusion portion **110**A is formed by eight protrusion parts **111**A extended along the tire circumferential direction.

FIG. **7** is an enlarged side view illustrating a part of the protrusion portion **110**A. As shown in FIG. **7**, the protrusion parts **111**A adjacent to each other are arranged with a gap **105**A therebetween so as to form a circle along the tire circumferential direction.

In the tire side view, the protrusion part **111**A includes an inner side portion **121**A extended along the tire circumferential direction at an inner side in the tire radial direction and an outer side portion **122**A extended along the tire circumferential direction at an outer side in the tire radial direction with respect to the inner side portion **121**A. Further, the protrusion part **111**A includes a first radial direction side portion **141** continued to one end of the inner side portion **121**A and one end of the outer side portion **122**A, and a second radial direction side portion **142** continued to the other end of the inner side portion **121**A and the other end of the outer side portion **122**A.

Further, a first narrow groove **210**A and a second narrow groove **220**A are formed on the protrusion part **111**A. Each of the first narrow groove **210**A and the second narrow groove **220**A is formed in an arc shape extended in the tire circumferential direction.

The first radial direction side portion **141** and the second radial direction side portion **142** are inclined in the same direction against the tire radial direction, in the tire side view. An inclined angle θ**1** of the first radial direction side portion **141** against the tire radial direction is smaller than an inclined angle θ**2** of the second radial direction side portion **142** against the tire radial direction. That is, the second radial direction side portion **142** is inclined against the tire radial direction more than the first radial direction side portion **141**. Accordingly, the gap **105**A is also formed to be inclined against the tire radial direction in accordance with the shape of each of the first radial direction side portion **141** and the second radial direction side portion **142**.

In this way, the protrusion part **111**A is different from the protrusion part **111** in the inclined angles of the first radial direction side portion **141** and the second radial direction side portion **142** against the tire radial direction. As shown in FIG. **2** and others, the radial direction side portion **131** of the protrusion part **111** is extended along the tire radial direction, namely extended parallel to the tire radial direction. On the other hand, the first radial direction side portion **141** and the second radial direction side portion **142** of the protrusion part **111**A are extended not to be parallel to the tire radial direction but to be inclined against the tire radial direction.

A rotation direction (see an arrow in FIG. **7**) of the pneumatic tire **10**A is designated, and when approaching the curbstone **300**, the first radial direction side portion **141** contacts the curbstone **300** first and then the second radial direction side portion **142** contacts the curbstone **300**.

According to such a protrusion portion **110**A, the first radial direction side portion **141** and the second radial direction side portion **142** are inclined against the tire radial direction such that a front end and a rear end of the protrusion part **111**A in the tire circumferential direction are tapered toward respective distal ends, and therefore an area of the protrusion part **111**A contacting the curbstone **300** can be substantially decreased at the front end and the rear end thereof. Consequently, the durability of the protrusion portion **110**A can be further improved.

Further, the shapes of the first narrow groove **210** and the second narrow groove **220** of the protrusion part **111** described above may be modified as below. FIG. **8** is a cross-sectional view illustrating a part of a tire side portion **100** including a protrusion part **111**B according to another modified example.

As shown in FIG. **8**, the protrusion part **111**B is formed such that a narrow groove **200** continued to a surface **110***s* of the protrusion part **111**B, specifically an outer end of the first narrow groove **210** in the tire width direction, is formed round without an edge, compared to the protrusion part **111** (see FIG. **4**). Specifically, an end **213** of the outer end of the first narrow groove **210** in the tire width direction is formed round. That is, the end **213** is formed in a shape having a curvature (round shape).

Similarly, an end **223** of the second narrow groove **220** is formed round to have a curvature (round shape).

According to the protrusion part **111**B, the stress is hardly concentrated on the end **213** and the end **223**, and thereby the durability of the protrusion part **111**B can be further improved.

Further, the shapes of the first narrow groove **210** and the second narrow groove **220** of the protrusion part **111** described above may be modified as below. FIG. **9** is a cross-sectional view illustrating a part of a tire side portion **100** including a protrusion part **111**B' according to another modified example.

As shown in FIG. **9**, the protrusion part **111**B' is different from the protrusion part **111**, in shapes of groove bottoms of the first narrow groove **210** and the second narrow groove **220**. Specifically, a groove bottom **210***b*' of the first narrow groove **210** is not formed in a sectional shape having a semicircular shape (bowl shape) like the groove bottom **210***b* (see FIG. **4**) but formed in a round shape in which a boundary between a linear bottom and a groove wall of the protrusion part **111**B' has a curvature. A groove bottom **220***b*' of the second narrow groove **220** is similar to the groove bottom **210***b*'.

With the shapes of the groove bottom **210***b*' and the groove bottom **220***b*' of the protrusion part **111**B', a possibility of a crack caused in the groove bottom **210***b*' and the groove bottom **220***b*' can be decreased, and thereby the durability of the protrusion part **111**B' can be further improved.

Further, the first narrow groove **210** and the second narrow groove **220** of the protrusion part **111** described above are terminated within the protrusion part **111**, however the first narrow groove **210** and the second narrow groove **220** may be opened to the radial direction side portion **131**.

FIG. **10** is an enlarged side view illustrating a part of a protrusion part **111**C according to the other modified example. As shown in FIG. **10**, a first narrow groove **210**C and a second narrow groove **220**C opened to the radial direction side portion **131** are formed on the protrusion part **111**C.

Specifically, an end **211**C of the first narrow groove **210**C and an end **221**C of the second narrow groove **220**C are opened to the radial direction side portion **131**.

The first narrow groove **210**C has a chamfered portion **212** for which a part of the first narrow groove **210**C continued to the surface **110***s* of the protrusion part **111**C is chamfered. Similarly, the second narrow groove **220**C has a chamfered portion **222** for which a part of the second narrow groove **220**C continued to the surface **110***s* of the protrusion part **111**C is chamfered. The chamfered portion **212** (chamfered portion **222**) is formed to be wider toward the end **211**C (end **221**C).

According to the protrusion part **111**C, since the end **211**C and the end **221**C are opened to the radial direction side portion **131**, the followability of the protrusion part **111**C to the deformation can be improved. Further, since the chamfered portion **212** (chamfered portion **222**) formed to be wider toward the end **211**C (end **221**C) is formed, although the first narrow groove **210**C (second narrow groove **220**C) is opened, it can be suppressed that the stress is concentrated on a specific part of the radial direction side portion **131**.

That is, according to the protrusion part **111**C, the followability of the protrusion part **111**C to the deformation can be improved while securing the durability thereof.

In the embodiments described above, two narrow grooves (first narrow groove **210** and second narrow groove **220**) extended in the tire circumferential direction are formed on the protrusion part **111**, however three narrow grooves or more extended in the tire circumferential direction may be formed on the protrusion part **111**. The number of the narrow grooves formed on the protrusion part **111** may be determined in accordance with a size (specifically, maximum width W1) of the protrusion part **111** in the tire circumferential direction. It is preferable to increase the number of the narrow grooves as the maximum width W1 becomes larger.

Further, in the embodiments described above, the protrusion part **111** is formed of a rubber material having a friction coefficient lower than that of the other part in the tire side portion **100**, however the rubber composition adopted for the protrusion part **111** may not be formed of the rubber material having a friction coefficient lower than that of the other part in the tire side portion **100**.

As described above, the embodiments of the present invention are described, however the present invention is not limited to the description and the drawings forming a part of the present disclosure. Various modifications, examples, and operation techniques will be apparent from the present disclosure to a person skilled in the art.

REFERENCE SIGNS LIST

10, **10**A: pneumatic tire
20: tread portion
30: bead portion
100: tire side portion
100*a*: side wall
105, **105**A: gap
110, **110**A: protrusion portion
110*s*: surface
111, **111**A, **111**B, **111**B', **111**C: protrusion part
121, **121**A: inner side portion
122, **122**A: outer side portion
131: radial direction side portion
132: chamfered portion
135: chamfered portion
141: first radial direction side portion
142: second radial direction side portion

150: adhesive rubber layer
200: narrow groove
210, **210**A, **210**C: first narrow groove
210*b*, **210***b*': groove bottom
211, **211**C: end
212: chamfered portion
213: end
220, **220**A, **220**C: second narrow groove
220*b*, **220***b*': groove bottom
221, **221**C: end
222: chamfered portion
223: end
290: road surface
300: curbstone
300*a*: side surface

The invention claimed is:

1. A tire comprising a protrusion portion protruded from a surface of a side wall toward an outer side in a tire width direction,

wherein the protrusion portion is formed by a plurality of protrusion parts extended along a tire circumferential direction,

wherein the protrusion parts are arranged with predetermined gaps therebetween to form a circle along the tire circumferential direction,

wherein a length of the protrusion part in the tire circumferential direction is larger than a maximum width of the protrusion part in a tire radial direction, and

wherein, in a tire side view, a narrow groove extended along the tire circumferential direction is formed on a surface of the protrusion part,

wherein both ends of the narrow groove are not opened to an end of the protrusion part in the tire circumferential direction but terminated within the protrusion part,

wherein the narrow groove includes at least a first narrow groove arranged at an inner side in the tire radial direction and a second narrow groove arranged at an outer side in the tire radial direction with respect to the first narrow groove,

wherein, in the tire side view, the protrusion part includes: an inner side portion extended along the tire circumferential direction at an inner side in the tire radial direction; an outer side portion extended along the tire circumferential direction at an outer side in the tire radial direction with respect to the inner side portion; a first radial direction side portion continued to one end of the inner side portion and one end of the outer side portion; and a second radial direction side portion continued to the other end of the inner side portion and the other end of the outer side portion,

wherein the first radial direction side portion and the second radial direction side portion are inclined in the same direction against the tire radial direction in the tire side view, and

wherein an inclined angle of the first radial direction side portion against the tire radial direction is smaller than an inclined angle of the second radial direction side portion against the tire radial direction.

2. The tire according to claim **1**, wherein an outer end of the narrow groove in the tire width direction continued to the surface of the protrusion part is formed round without an edge.

3. The tire according to claim **1**, wherein, in the tire side view, the protrusion part is formed in an arc shape having a predetermined width in the tire radial direction, and

wherein, in the tire side view, a corner of the protrusion part is chamfered.

4. The tire according to claim **1**, wherein a distance between an outer end of the protrusion part in the tire radial direction and an outer end of the second narrow groove in the tire radial direction is longer than a distance between an outer end of the first narrow groove in the tire radial direction and an inner end of the second narrow groove in the tire radial direction.

5. The tire according to claim **4**, wherein a groove bottom of the narrow groove is formed round without an edge in a sectional view along the tire width direction and the tire radial direction.

6. The tire according to claim **4**, wherein an outer end of the narrow groove in the tire width direction continued to the surface of the protrusion part is formed round without an edge.

7. The tire according to claim **1**, wherein a distance between an inner end of the protrusion part in the tire radial direction and an inner end of the first narrow groove in the tire radial direction is longer than a distance between an outer end of the first narrow groove in the tire radial direction and an inner end of the second narrow groove in the tire radial direction.

8. The tire according to claim **7**, wherein a groove bottom of the narrow groove is formed round without an edge in a sectional view along the tire width direction and the tire radial direction.

9. The tire according to claim **7**, wherein an outer end of the narrow groove in the tire width direction continued to the surface of the protrusion part is formed round without an edge.

10. The tire according to claim **1**, wherein a groove bottom of the narrow groove is formed round without an edge in a sectional view along the tire width direction and the tire radial direction.

11. The tire according to claim **10**, wherein an outer end of the narrow groove in the tire width direction continued to the surface of the protrusion part is formed round without an edge.

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